Best Available Science

Landslide Hazard Areas

Prepared for the City of Sammamish
by AMEC Environment and Infrastructure Inc.

Introduction

The City of Sammamish (Sammamish) is in the process of reviewing its Environmental Critical Areas regulations (ECA). Designation and protection of environmentally critical areas must include Best Available Science (BAS) according to the Growth Management Act (GMA, RCW 36.70A). This memo provides a summary of the BAS relevant to landslide hazard areas (SMC 21A.50.260), and focuses on scientific review articles and government agency guidance documents that have been published since Sammamish last updated its ECA codes in 2005. The intent is to characterize accurately the general conclusions of existing studies and to provide a context for updating the existing ECA. Available studies pertaining to landslide hazards within the Puget Sound region from 2005 through 2012 were reviewed. Where applicable, recent research was used to comment on the current ECA code or City concerns.

Puget Sound-Wide Issues

Landslides within the Puget Sound region have been studied for decades. Our research revealed that studies of landslide hazards within the Puget Sound region have focused almost entirely on the City of Seattle. The majority of landsliding in the region has been found to be attributed to geologic, climatic, and human factors (Tubbs, 1975). Landslides have been associated with concentrated winter precipitation, steep slopes, and glacial soils that are susceptible to instability (Laprade and Tubbs, 2008). Since the 2005 BAS report for the City was completed we found that the most significant technological advances pertaining to landslide hazards were: the improved ability to map landslide areas using a technique called Light Distance and Ranging (LIDAR) which provides more detail than an aerial photograph in highly vegetated areas, and by forecasting the occurrence of landslides based on cumulative rainfall totals.

Forecasting Landslides

Scientists at the USGS (Baum et al, 2007) have developed methods and formulas based on past rainfall amounts to identify when landslides are likely. These formulas are called “precipitation thresholds.” Two thresholds have been developed for the Seattle area. The first one, called the Cumulative Precipitation Threshold, tracks precipitation over the last 18 days and indicates when the ground is wet enough to be susceptible to landslides. Between 3.5 and 5.3 inches of rain are required to exceed this threshold, depending on how much rain has fallen in the last 3 days. The second, called the Intensity Duration Threshold, tracks rainfall during a storm and indicates when it is raining hard enough to cause multiple landslides if the ground is already wet.

Identification of Landslide Hazard Areas

Recent studies (Baum et al, 2007) demonstrate the improvements in identification of potential landslide areas using LIDAR. Researchers have found that LIDAR provided a much more thorough delineation of previous landslide areas and identified many heavily vegetated or undeveloped sloping areas within Seattle that have the potential for landsliding. The City of Sammamish has LIDAR maps of the landslide hazard areas.

Development Issues in Landslide Hazard Areas

New development or redevelopment of property near landslide hazard areas has become a more contentious issue as more and more property owners attempt to maximize the developable portions of their land and views within ECA code constraints. Many jurisdictions require site-specific studies to assess site conditions, evaluate the risks, and identify the potential impacts of and mitigation for development proposals in geologic hazard areas. The site-specific information required to review development proposals qualifies as the best available science, both for providing relevant and accurate information about site conditions and identifying the mitigation measures necessary to reduce the risk and impacts of a specific proposal (WAC 365-195-905). In determining the adequacy of site-specific ECA studies, many jurisdictions do not have qualified geologists or geotechnical engineers on staff to review the reports, and so they either require or have the option of a third-party independent geotechnical review. Additionally, without such standards, the incentive for the developer is to produce the least expensive (and thus, least thorough) report possible, especially on single-family residential developments. Other cities have detailed geotechnical report requirements specified in their codes to ensure minimum reporting requirements are met and to improve the review process.

Unique Conditions in Sammamish

Recent geologic mapping of King County (Booth and Wisher, 2006) identifies the City as being underlain primarily by glacially derived or glacially overridden soils (Figure 1). Steep slopes, found where the highlands descend to Lake Sammamish and within natural drainages such as ravines, are typically comprised of looser alluvial soils or recessional outwash overlying denser glacial soils, such as glacial till or advance outwash. The most common landslides occur where there is a veneer of looser soils overlying the denser soils on steeply inclined hillsides. These types of areas are included in the City's ECA definition of landslide hazard areas as well as other types of areas that are potentially subject to risk of landslides due to geologic, topographic and hydrologic conditions.

Based on review of the City's geologic hazards map and recent mapping by King County (King County, 2010) (Figure 2), we find that identified landslide hazard areas remain essentially unchanged. These areas are often associated with steep slopes and primarily occur along the western perimeter of the City where the highlands descend to Lake Sammamish, or within steeply incised natural drainages. In addition, along the northern boundary of the City, there are landslide hazard areas associated with steep slopes that descend to the lowlands of Evans Creek (along SR-202).

Implications for Existing City Regulations

Based on review of ECA codes of similar jurisdictions and our experience with other jurisdictions within Puget Sound, ECA codes generally protect landslide hazard areas by establishing buffers from landslide hazards and restricting activities within buffers. In some cases, key terms are not defined specifically, which has led to disputes and litigation. This is discussed further in the Code Definitions Section.

Landslide Hazard Area Buffers

Per SMC 21A.50.260(1), a standard 50-foot buffer is required from all edges of a landslide hazard area. This is the standard buffer width adopted by many jurisdictions, and many jurisdictions allow the buffer to be reduced based on site-specific studies, including the City of Sammamish. Review of available literature indicates no new science to suggest changing the standard. In our experience, 50 feet is a supportable standard buffer regardless of gradient, because most landslides occur less than 50 feet beyond the top and toe of the slope and most landslide are not affected by site development more than 50 feet beyond the top and toe of the slope.

Concerning the code language, there is no definition within the SMC as to what constitutes the "edge" of a landslide hazard area. We recommend establishing the buffer from the "top" and "toe" of landslide hazard areas related to steep topography and landslide hazards related to geology. Additionally, for landslide hazard areas based on geologic conditions, such as areas of previous movement, the edges or sides may need to be identified by site specific studies. This is discussed further in the Code Definitions Section.

Flexibilities in Code Regarding Landslide Hazard Areas

***Buffer Reduction**:* Most jurisdictions, including the City of Sammamish, allow the code-specified buffer to be reduced based on site-specific studies that include an evaluation of the slope stability. (SMC 21A.50.260(2)) This is supportable because some specific slopes that meet the definition of a landslide hazard area may be relatively stable and do not need 50 feet of buffer to remain stable. Site-specific studies are needed to determine site-specific buffers (WAC 365-195-905).

Waiving of Critical Areas Study: SMC 21A.50.260(2)(a) currently allows the City to waive the requirement for a "critical areas study requirement if other development in the area has already provided sufficient information or if such information is otherwise readily available." In our experience, a critical areas study should be required for all sites regardless of proposed development. However, we recognize that critical area studies may be available for adjacent properties that could be reviewed, and that the scope of work would depend on the specific site and type of development proposed. We recommend eliminating SMC 21A.50.260(2)(a). It is not necessary if the City understands that the scope of work for a critical areas study depends on the site and the proposed development.

Exempt Slopes: SMC 21A.50.260(7) allows an exemption for landslide hazard areas and steep slopes up to 20 feet high. Similar exemptions are offered by other jurisdictions. It should be noted that in the Seattle Landslide Study (2001) database, about 15% of the reported landslides had slope height of 20 feet or less, and there were only a few landslides reported for slopes up

to 10 feet. We recommend the City consider whether they wish to keep this exemption. While BAS indicates that there is some risk of allowing this exemption, it is a policy decision as to how much risk is acceptable.

Infiltration adjacent to Landslide Hazard Areas

Based on our research, BAS does not support requiring specific drainage improvements, such as on-site infiltration, within landslide hazard area buffers (King Co., 2009). Engineering geology concepts are generally opposed to introducing a water source that could destabilize slopes (Turner and Schuster, 1996). We would recommend deleting SMC 21A.50.260 (6). The topic of stormwater infiltration should be addressed in the City's stormwater design manual rather than the ECA. (For example, see the King County Stormwater Management Design Manual (2009) Section 5.4.1 General Requirements for Infiltration Facilities – Infiltration near Steep Slopes and Landslide Hazard Areas.)

Independent Third Party Review of Geotechnical Reports

As mentioned above, many jurisdictions require independent third party review of geotechnical reports; however, Sammamish currently does not. We recommend that Sammamish allow for the third party reviews, at the City's option, with cost of the review administered by the City and borne by the applicant.

Slope stability

Per SMC 21A.50.260 (2)(b)(iv and vii), an estimate of slope stability needs to be completed as part of a critical areas study. This is a key component of assessing the existing slope stability pre- and post-development. However, the City's code does not define a stable slope. Other jurisdictions (Bainbridge Island, 2008) specify a minimum factor of safety for slope stability that must be achieved for static conditions and seismic conditions. Factor of safety is the ratio of the forces resisting slope movement to the forces driving it. Thus, factor of safety values greater than 1.0 indicate stability while those less than 1.0 indicate instability. We recommend that buffers be established so that any development near the slope has a minimum factor of safety for slope stability of 1.5 for static conditions and 1.1 for seismic conditions, based on current building code seismic design conditions (WSDOT, 2012).

Code Definitions

1. **Slope**

Our experience consulting for other cities suggests that the City definition of slope should be more specific (City of Shoreline, 2011). We recommend moving SMC 21A.15.1230 to be part of the definition in SMC 21.A.15.680 and adding to the definition. Currently it says the "toe" and "top" of slope is defined as a "distinct topographic break in a slope." However, the term "distinct topographic break" should be defined in a measureable way to minimize differing interpretations. For example, the following sentence could be added as the second sentence: "A distinct topographic break is where the change in gradient is less than 5 feet vertically within a horizontal distance of 25 feet." This measurement is suggested because it represents a slope gradient of 20%, which is 50% flatter than the definition of a steep slope, and it uses the same horizontal distance that is used in the latter part of the existing definition.

2. Geologist

Per SMC 21A.15.545, "Geologist" means a person who has earned at least a Bachelor of Science degree in the geological sciences from an accredited college or university or who has equivalent educational training and at least four years of professional experience.

We recommend updating the definition to, "A professional geologist licensed in the State of Washington." The licensing of geologists became a requirement in the State of Washington in 2000 (WAC 308-15) and is not currently reflected in the SMC.

3. Qualified professional

Per SMC 21A.15.942, subsection (2), Identification of geologic hazards may be performed by geologists or other geology professionals with experience identifying geologic hazards.

The identification of geologic hazards should be performed by a licensed geologist (which includes licensed geotechnical engineers) in the state of Washington, in accordance with our previous comment.

Table 1. Recommended Changes to the Sammamish Environmentally Critical Areas Code

Recommended Code Amendment	Best Available Science	Professional Experience	Statutory / Case Law
Revise the standard within SMC 21A.50.260(1) for buffer to be from top and toe of slope instead of from edge		A revision of the standard for where the buffer is located would be consistent with other ECA codes from peer jurisdictions and less likely misinterpreted.	
Revise SMC 21A.50.260 (2)(a) so that critical areas studies cannot be waived		Based on review of numerous geotechnical reports for planned developments in landslide hazard areas for several cities within the Puget Sound region, it is our opinion, that a critical areas study should be completed in all cases, but the scope of the study will depend on the site and the proposed development	
The City should consider whether to allow slopes up to 20 feet high to be exempt per SMC 21A.50.260(7). (While BAS indicates that there is some risk of allowing this exemption, it is a policy decision as to how much risk is acceptable.)	Seattle Landslide Study, 2001		City of Shoreline, 2011
Delete SMC 21A.50.260 (6) regarding drainage design in landslide hazard areas	King Co. 2009	Peer jurisdictions do not specify drainage design in their ECA codes. The topic of stormwater infiltration should be addressed in the City's stormwater design manual rather than the ECA.	
Add an option for the City to have a third party review of geotechnical reports in landslide hazard areas	WAC 365-195-905	Peer jurisdictions with landslide hazard area regulations have provisions for third party review of critical areas reports and geotechnical evaluations.	
Revise SMC 21A.50.260 (2)(b) to include specified minimum static and seismic factors of safety for slope stability	WSDOT, 2012	Peer jurisdictions have specified minimum factors of safety for slope stability.	

Recommended Code Amendment	Best Available Science	Professional Experience	Statutory / Case Law
Revise SMC 21A.15.680 to include a definition of distinct break within a slope			City of Shoreline, 2011.
Revise definition of geologist in SMC 21A.15.545 to licensed geologist			Peer jurisdictions have updated definition based on Washington State licensing of geologists in 2000. (WAC 308-15)
Revise the definition of qualified professional SMC 21A.15.942 (2) regarding identification of geologic hazards by a licensed geologist			To required that geologists are licensed in the State of Washington (WAC 308-15)

Research or Monitoring Needs

None noted.

Specific References

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City of Bainbridge Island, Bainbridge Island Municipal Code 16.20.150.

City of Shoreline Hearing Examiner Findings, Conclusions and Decision, Project Number 115423, October 20, 2011.

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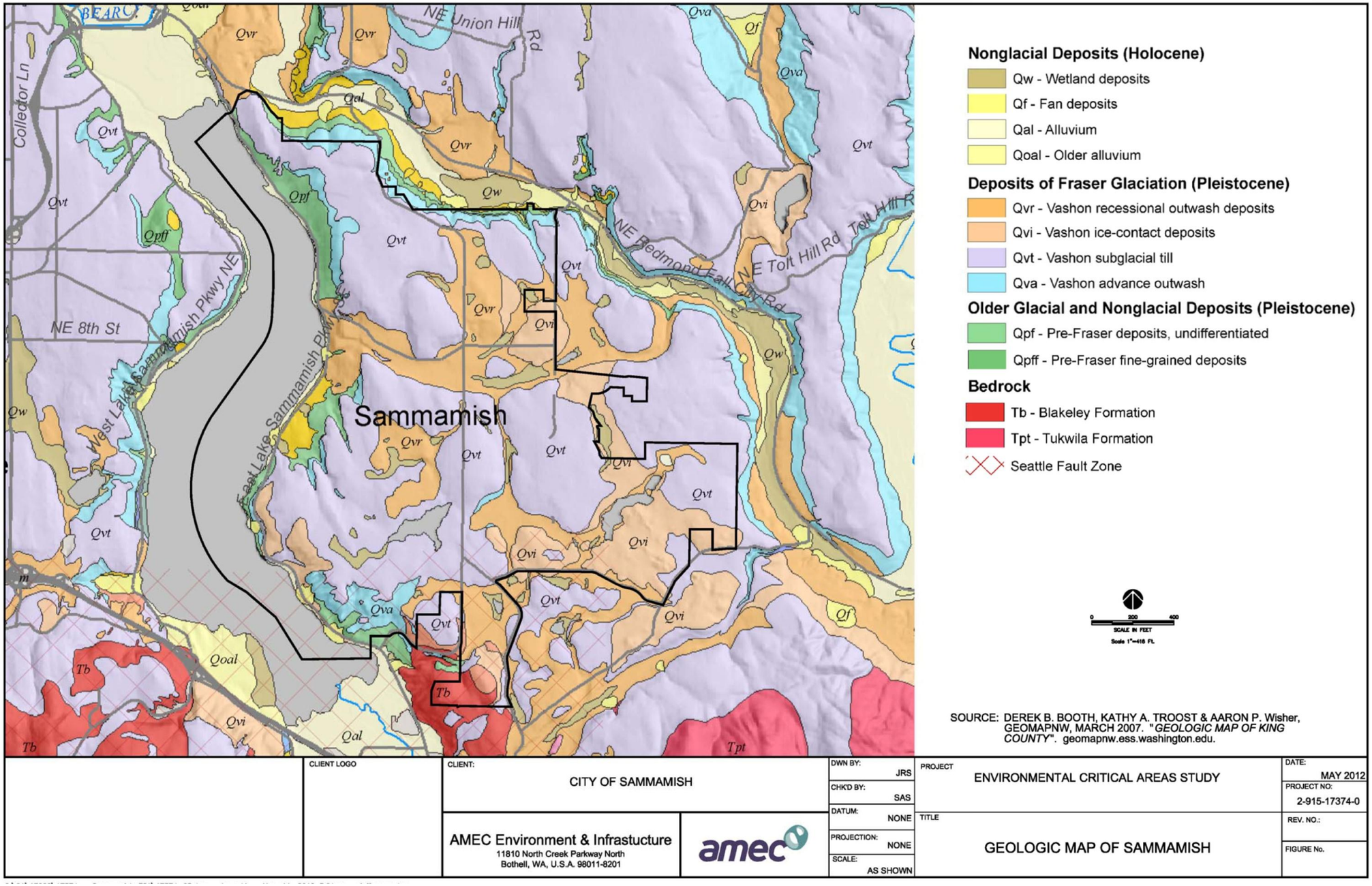
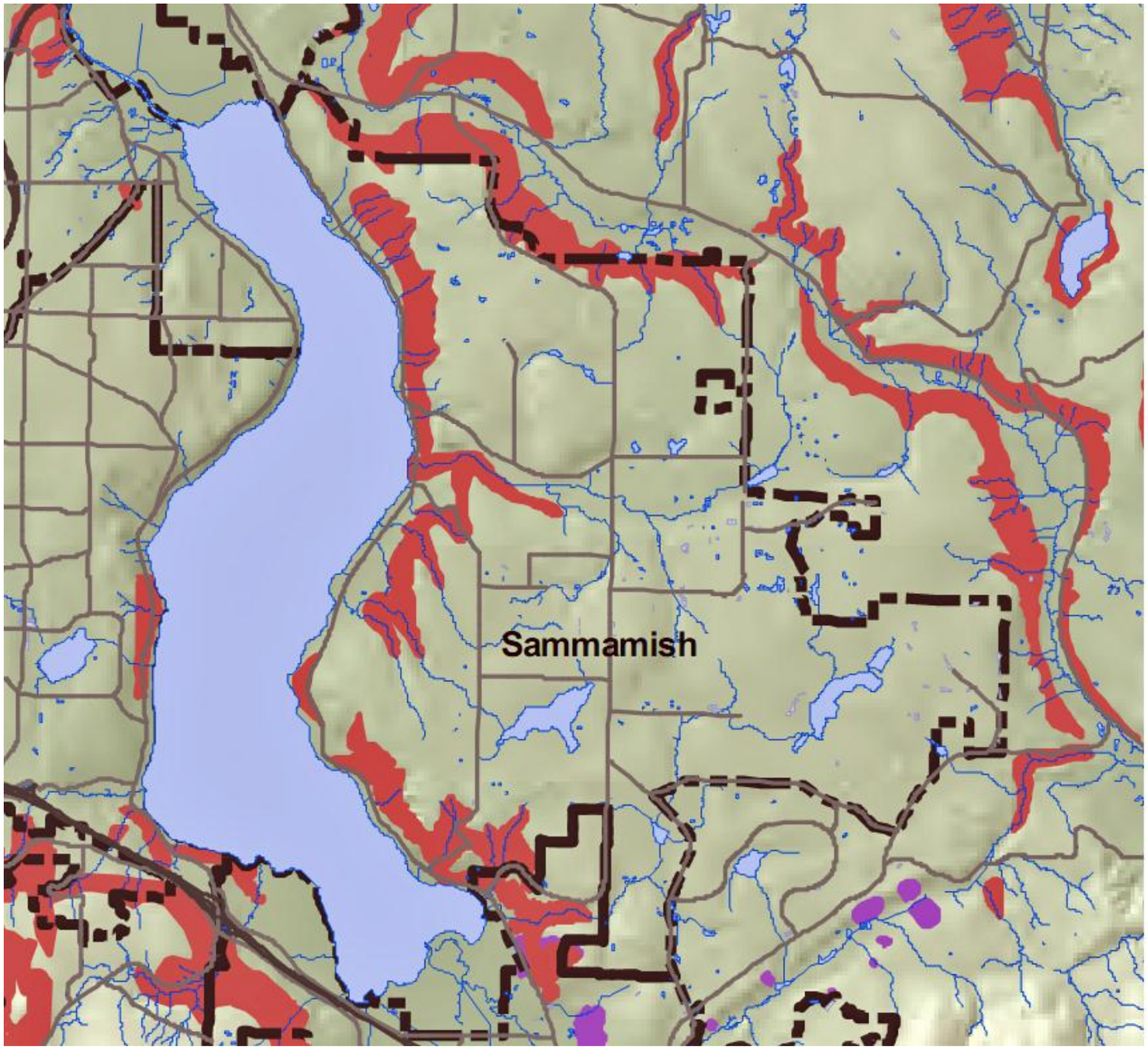


Figure 1. Surficial Geology of the City of Sammamish (Note: the City Limits line may not be up to date)



Map 12-1

Landslide Hazard Areas

King County Landslide Hazard Areas

King County Landslide Hazard Areas are areas subject to severe landslide risk identified in the Sensitive Areas Ordinance.

DNR Landslide Hazard Areas

The Department of Natural Resources, Geology and Earth Resources Division (DGER) Landslide dataset is a compilation of landslide data previously mapped by a variety of sources at all scales, and is assessed for reliability by the DGER.

Data Sources:
King County GIS
US Geological Survey
Washington State Department of Natural Resources, Division of Geology and Earth Resources
Tetra Tech, Inc.
May 2010

0 2.5 5 10 Kilometers

0 2.5 5 10 Miles

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KING COUNTY FLOOD CONTROL DISTRICT

Figure 2. Landslide Hazard Areas s in the City of Sammamish (Note: the City Limits line may not be up to date).